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Effectiveness Of Compliance Nutrition And Physical Activity Interventions In Diabetes Management: A Systematic Review

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ABSTRACT

Type 2 diabetes has developed into a global epidemic with a significant increase in prevalence, both in the world and in Indonesia. This disease not only impacts quality of life, but also places a large economic burden on the health care system. Although most diabetes interventions still focus on pharmacological treatment, non-pharmacological approaches such as nutritional interventions and increased physical activity have been shown to be effective in lowering blood glucose levels, increasing insulin sensitivity, and improving patients' metabolic profiles. However, the effectiveness of these interventions is highly dependent on patient compliance. Compliance with these interventions is influenced by psychological, socioeconomic, and health literacy factors. Intrinsic motivation and positive perceptions of the disease can increase patient commitment, while stress, depression, and limited access to healthy food and sports facilities can hinder compliance. High health literacy affects patients' understanding of treatment and their readiness to make behavioral changes. Approaches based on education, social support, and the use of digital technology can strengthen diabetes management and improve patient compliance. Therefore, effective interventions require a more personalized, interdisciplinary approach that is oriented towards long-term behavioral change to achieve sustainable results.

Keywords: Effectiveness-Compliance; Nutrition-Intervention; Type-2-Diabetes-Management

INTRODUCTION

Diabetes mellitus, especially type 2, has developed into a global epidemic that has shown a consistent trend of increasing prevalence in the last two decades. According to the 2021 International Diabetes Federation (IDF) report, the number of diabetes sufferers in the world has reached more than 537 million people and is expected to increase to 643 million by 2030 if there is no significant intervention. In Indonesia itself, the 2018 Riskesdas data shows that the prevalence of diabetes mellitus based on doctor's diagnosis and symptoms increased from 6.9% (2013) to 8.5% (2018). This increase not only impacts the quality of life of individuals but also creates a large economic burden on the health care system. This disease is closely related to an increased risk of chronic complications such as heart disease, kidney failure, neuropathy, and visual impairment which lead to decreased productivity and increased premature mortality.

The massive increase in the prevalence of diabetes also highlights gaps in the prevention and management system of non-communicable diseases, especially in the aspect of the lifestyle of modern society which tends to be sedentary and consumes high-calorie foods. Most diabetes management strategies are still too focused on

pharmacological treatment, whereas non-pharmacological approaches such as nutritional interventions and increased physical activity have been shown to delay disease progression and even improve metabolic conditions significantly. A study by Abdelrazig (2021) through the Diabetes Prevention Program (DPP) showed that lifestyle modification can reduce the incidence of diabetes by up to 58%, much more effective than single metformin therapy. However, the effectiveness of these interventions is greatly influenced by the consistency and compliance of patients in implementing them. Therefore, the increase in the prevalence of diabetes is not only an indicator of systemic failure in primary prevention, but also shows the importance of reviewing existing approaches and integrating behavioral and compliance-based strategies into a more sustainable diabetes management framework.

Nutritional interventions and physical activity are two central elements in the non-pharmacological management of type 2 diabetes that have been scientifically proven to lower blood glucose levels, increase insulin sensitivity, and improve the patient's metabolic profile. Global recommendations such as those conveyed by the American Diabetes Association (ADA) emphasize the importance of a balanced diet with a low glycemic index and aerobic physical activity of at least 150 minutes per week (Harna et al., 2022). However, the effectiveness of these interventions is largely determined by the level of patient compliance in implementing them consistently. Many patients face structural barriers such as economic constraints, low health literacy, and lack of social support, resulting in a gap between knowledge and actual practice in daily life. Thus, the success of interventions cannot be measured solely from the clinical aspect, but also needs to consider the social and behavioral dimensions that affect the patient's long-term participation.

Furthermore, low levels of adherence are a significant challenge that often hinder optimal outcomes from diabetes management programs. A longitudinal study by MacDonald et al. (2021) showed that despite intensive education, only about 30% of patients maintained adherence to diet and exercise six months after the intervention. This confirms that education is necessary, but not sufficient. An effective management approach should include behavioral modification strategies, emotional support, and the use of digital technologies such as personalized and adaptive health monitoring applications. Therefore, a systematic review of the effectiveness of adherence in nutrition and physical activity interventions is crucial to formulate an intervention model that is not only evidence-based, but also contextual and sustainable in practice.

One of the root causes of low patient compliance with nutrition and physical activity interventions lies in the complexity of interacting psychosocial factors. Patients with high levels of stress, depression, or anxiety tend to show lower compliance with diabetes management plans, as revealed by Sundari et al. (2019) who found a significant negative correlation between diabetes distress and medication compliance and healthy lifestyle. In addition, economic limitations are also a major barrier, where patients often have difficulty accessing healthy food or adequate sports facilities. These barriers are exacerbated by a lack of understanding of the benefits of non-pharmacological interventions and low health literacy, which makes patients rely more on drug therapy alone without realizing the important role of lifestyle changes in the long term.

Equally important, culture and social norms also shape a person's mindset, eating habits, and activities. In certain societal contexts, consuming foods high in fat and carbohydrates is often part of social interactions or cultural values, making dietary changes a challenge in itself. A study by Zairina et al. (2022) showed that the public's perception of diabetes as a "common" chronic disease that does not need to be treated proactively also influences patient motivation to comply. This indicates that the success

of an intervention is determined not only by the design of the program, but also by its sensitivity to the cultural and social context in which the patient is located. Therefore, a more personal, interdisciplinary, and long-term behavioral change-oriented intervention approach is needed, not just the delivery of information.

Systematic reviews of the effectiveness of adherence in nutrition and physical activity interventions are important not only to measure clinical success but also to identify key elements that determine the sustainability of behavior change. Many studies have shown short-term success of interventions, but many have reported a decline in adherence after several months, indicating that initial success does not guarantee sustained impact (Mandowa, 2022). Therefore, systematic evaluations should include temporal and contextual dimensions of adherence, including motivational reinforcement strategies, monitoring methods, and patient social engagement. This approach is needed to comprehensively understand why some interventions are successful in certain populations but fail to be implemented widely in the community or health care system.

In addition, the results of systematic reviews can provide an empirical basis for policy making and the development of clinical guidelines that are more adaptive to patient needs. Currently, many clinical guidelines are still normative and do not fully consider individual variability in responding to lifestyle-based interventions. By synthesizing data from various studies that focus on the relationship between adherence levels and clinical outcomes such as HbA1c levels, body mass index, and blood pressure, researchers and policy makers can design more targeted interventions. For example, a meta-analysis study by Karingga et al. (2024) showed that an approach that integrates social support and digital technology has a significant impact on improving adherence and health outcomes in patients with diabetes. Thus, systematic reviews not only serve as evaluative tools, but also as a foundation for sustainable and contextual intervention innovation.

METHOD

This study uses a qualitative approach with a systematic literature study method to evaluate the effectiveness of adherence to nutritional and physical activity interventions in the management of type 2 diabetes. Literature studies were chosen because they are able to provide an in-depth understanding of the results of previous studies and factors that influence patient adherence.

Data were collected through searching scientific articles from databases such as PubMed, Scopus, and Google Scholar, with a span of 2013–2023. Keywords used include: “adherence,” “dietary intervention,” “physical activity,” and “type 2 diabetes.” The selected articles are relevant primary research or systematic reviews that have gone through a peer-review process.

The analysis was conducted thematically, to identify key patterns of findings, such as barriers to adherence, intervention strategies, and their impact on clinical outcomes (e.g. HbA1c). The results of the analysis were synthesized narratively to provide a comprehensive picture of the effectiveness of adherence in lifestyle interventions

RESULTS AND DISCUSSION

Factors Influencing Compliance with Nutrition and Physical Activity Interventions

1. The Role of Psychological Factors in Patient Compliance

Patient compliance with nutritional and physical activity interventions is not only determined by physical or medical aspects, but is also greatly influenced by underlying psychological conditions. One key aspect is motivation, which is divided into intrinsic and

extrinsic motivation. Intrinsic motivation—such as the desire to live a healthy life, feel better physically and emotionally—has been shown to be more sustainable in driving long-term lifestyle changes than extrinsic motivation, such as pressure from the surrounding environment. In addition to motivation, patient perceptions of the disease and the benefits of the intervention also greatly determine the level of compliance. According to the Health Belief Model (Rosenstock, 1974), individuals who feel vulnerable to disease complications and believe that interventions such as healthy diet and exercise can prevent worsening conditions will be more motivated to act. Therefore, a realistic and positive perception of the disease and its healing efforts is an important foundation in increasing compliance.

On the other hand, negative psychological conditions such as stress and anxiety are often major obstacles in implementing health interventions. Chronic stress can decrease cognitive function, disrupt emotional regulation, and lead to compulsive behaviors such as emotional eating or avoiding physical activity. Syahid (2021) showed that unmanaged stress contributes to decreased self-control and increased tendency to consume foods high in sugar and fat. More seriously, depression is known to significantly reduce compliance with medical advice. Al Fatih et al. (2024) found that patients with chronic diseases such as diabetes who experience depression are twice as likely to fail to adhere to medication and a healthy lifestyle, compared to patients without mood disorders. Depressive symptoms such as fatigue, anhedonia (loss of interest), and feelings of helplessness directly interfere with patients' ability to maintain healthy habits.

Based on these findings, it is clear that psychological factors are not just supporting elements, but are core components in the success of medical interventions. Effective interventions need to integrate psychosocial approaches, such as counseling, cognitive-behavioral therapy (CBT), stress management, and patient empowerment through empathetic education. Lifestyle intervention programs accompanied by psychological support significantly increase patient adherence to diet and physical activity (Mauldy & Ibnu, 2024; Prats-Arimon et al., 2024). In addition, the quality of the relationship between patients and health workers has also been shown to influence adherence. In a meta-analysis by Wasir et al. (2024), it was found that empathetic communication and patient involvement in the decision-making process increased adherence. Therefore, it is important for health workers to not only focus on medical instructions, but also on the patient's psychological condition as an integral part of a holistic approach. By considering the psychological dimension as a whole, nutritional and physical activity interventions have a greater chance of success and providing sustainable results for patients.

2. Socio-Economic Influences and Environmental Support

A person's socioeconomic status (SES) has a significant influence on their health status, as evidenced by various epidemiological studies. Research from the World Health Organization (WHO, 2013) shows that individuals from low-income groups are more susceptible to chronic diseases such as type 2 diabetes, hypertension, and obesity. This is due to limited access to nutritious food, sports facilities, and preventive health services. Healthy foods, such as fresh vegetables, fruits, and lean protein sources, tend to be more expensive and less available in areas with low economic status, known as food deserts. In addition, public facilities for exercise such as parks or bike paths are often unavailable or poorly maintained in dense and less safe environments, limiting opportunities for regular physical activity.

On the other hand, limited access to health services also has an impact on quality of life and disease management. A study by Djati (2023) confirmed that the gap in access to medical services creates inequality in public health outcomes. Individuals from low-

income backgrounds often do not have health insurance or face time constraints due to high workloads, so they cannot undergo regular health checks. However, social factors such as family support and social environment have been shown to moderate these negative impacts. A supportive family can increase patient compliance with treatment and encourage healthier lifestyle changes.

Furthermore, community-based interventions have been shown to be an effective strategy in addressing socio-economic challenges to health. The importance of social capital and a sense of ownership in the community to build collective awareness of health. Community programs such as elderly exercise, RW/RT-based nutrition education, and chronic disease support groups have been shown to be effective in increasing long-term adherence to treatment and healthy lifestyles. An active community also creates positive peer influence that can reinforce healthy behaviors in a sustainable manner. Thus, although socio-economic status can be a barrier to achieving optimal health, the presence of social support and structured community interventions can help individuals survive and thrive in a sustainable healthy lifestyle.

3. Health Literacy and Readiness for Behavior Change

Health literacy is an important foundation in efforts to prevent and manage chronic diseases, including type 2 diabetes mellitus. Health literacy not only includes the ability to read and understand medical information, but also involves cognitive and social skills that enable individuals to access, interpret, and use the information to make appropriate decisions in the context of health (Batubara et al., 2020). In the context of diabetes management, health literacy affects the extent to which patients are able to understand the relationship between lifestyle—such as diet and physical activity—and their blood glucose levels. Patients with adequate literacy are better able to follow medical instructions, understand the consequences of non-adherence to treatment, and manage symptoms and complications independently. Longitudinal studies have found that diabetic patients with low literacy have worse glycemic control (higher HbA1c) and higher hospitalization rates compared to those with higher literacy (BN et al 2019; ALSharit & Alhalal, 2022). These results were reinforced by Safitri & Syafiq (2022) who showed a strong relationship between low health literacy and poor patient understanding of diabetes education and low compliance with treatment regimens.

On the other hand, the level of health literacy interacts closely with an individual's readiness to make behavioral changes, which is a crucial element in lifestyle-based diabetes management. The Transtheoretical Model of Behavior Change (TTM) theory developed by Prochaska and DiClemente (1983) explains that behavioral change occurs through a series of stages: precontemplation, contemplation, preparation, action, and maintenance. Each stage requires a different intervention approach, depending on the individual's motivation and understanding. Patients with low health literacy tend to be stuck in the precontemplation or contemplation stage because they do not fully understand the urgency of lifestyle change or do not have enough knowledge to realistically plan for change. Health education interventions tailored to literacy levels have been shown to increase readiness for behavioral change and increase active participation in self-care. Similarly, Farida (2018) reported that increasing health literacy through community-based interventions can accelerate patients' transition to the action and maintenance stages, as well as improve overall clinical outcomes.

Therefore, a one-size-fits-all approach is not effective in educating patients with diabetes. Intervention programs must be adaptive, namely considering the variation in literacy levels and readiness for behavioral change of each individual. The delivery of information must be adjusted, not only in terms of language, but also in terms of format,

cultural context, and communication methods, such as the use of visual media or direct experience-based training. Involvement of families, health cadres, or peer group support has also been shown to increase patient engagement, especially those who are in the early stages of behavior change. By integrating an understanding of health literacy and behavioral readiness into intervention design, health care providers can create programs that are not only informative, but also transformative and sustainable in helping patients manage diabetes effectively.

Effectiveness of Adherence-Based Interventions in Improving Diabetes Clinical Outcomes

1. Relationship of Compliance with Improvement of Clinical Parameters

Compliance with non-pharmacological interventions, especially in the form of dietary regulation and increased physical activity, is a key pillar in the management of type 2 diabetes mellitus. This disease is chronic and progressive, so that the management strategy does not only focus on temporary blood glucose control, but also on long-term lifestyle changes. High compliance with lifestyle interventions has been shown to improve various important clinical parameters, such as decreased glycated hemoglobin (HbA1c) levels, weight loss, and improved blood pressure control. A large meta-analysis study conducted by Samudera et al (2020) included 47 studies and showed that structured physical activity programs, especially those lasting more than 12 weeks, can reduce HbA1c levels by an average of 0.66%. This decrease is comparable to the effectiveness of several oral glucose-lowering drugs, confirming that lifestyle changes have a real therapeutic impact and are no less important than pharmacological interventions.

In addition, the positive effects of adherence to a healthy diet and physical activity have also been proven in a study by Ningrum, et al (2022), which showed that intensive lifestyle changes can reduce the risk of developing type 2 diabetes by up to 58% in individuals with prediabetes. In the context of patients already diagnosed with diabetes, similar results were found in the UK Prospective Diabetes Study (UKPDS), which stated that consistent good blood glucose control that is only possible through adherence to lifestyle interventions and medication is correlated with a reduced risk of microvascular and macrovascular complications. In other words, adherence not only helps achieve glycemic targets, but also contributes greatly to the prevention of long-term complications that often reduce the patient's quality of life.

In clinical practice, adherence also serves as an indicator of patient involvement in their self-care process. Patients who demonstrate high adherence tend to have a better understanding of their illness, feel in control of their health, and are more responsive to feedback from health workers. However, it is important to understand that adherence is not something that occurs automatically; it is influenced by various factors, such as education level, socio-economic status, family support, and the patient's relationship with health workers. Therefore, educational and participatory interventions, including nutritional counseling, self-management programs, and community support, have been shown to be more effective in improving adherence than instructional approaches alone.

Overall, scientific data and evidence show that adherence is a central component in the success of non-pharmacological interventions in type 2 diabetes. Not only does it help control blood glucose and weight, but it also directly reduces the risk of complications and improves long-term quality of life. Therefore, diabetes management strategies should not only focus on medical therapy, but also include intensive efforts to improve patient adherence through a holistic and sustainable approach.

2. **Effectiveness of Technology and Community-Based Interventions**

Innovations in technology-based and community-based health interventions have become an integral part of strategies to increase patient engagement in the management of chronic diseases, such as diabetes, hypertension, and heart disease. As the digital era advances, various technology-based solutions are beginning to be utilized to bridge the limitations of conventional health care systems. Technologies such as health-tracking apps, telehealth services, and community-based communication platforms enable patients to be more active in the medical decision-making process. This is in line with the patient-centered care approach that emphasizes the importance of active patient participation as partners in their health management. According to the World Health Organization (WHO), patient empowerment through technology can increase adherence to therapy by up to 50%, which has a direct impact on long-term clinical outcomes.

One of the most significant benefits of digital-based interventions is the increased regularity in recording daily health data, such as physical activity, food intake, sleep quality, and adherence to taking medication. A study by Hananto et al. (2022) showed that patients who used monitoring applications consistently experienced significant improvements in blood glucose management. This finding is supported by a meta-analysis conducted by Widyanata (2018), which concluded that mobile application-based digital interventions can reduce HbA1c by 0.4% to 0.8% in patients with type 2 diabetes. This effectiveness comes from the application's ability to provide automatic reminders, personalized health education, and real-time feedback based on the data collected, all of which support sustainable healthy behavior changes.

In addition to technology, the role of the community in supporting the success of the intervention is also very important. Peer support groups have been shown to provide significant psychosocial benefits, such as reduced loneliness, increased motivation, and the formation of a sense of collective responsibility for maintaining health. Research by Fajriyah et al (2020) revealed that support from peers in community groups can significantly improve glycemic control in diabetes patients, even exceeding the effects of several clinic-based interventions. In the context of a collective culture such as in Indonesia, a community-based approach has its own advantages because it utilizes the values of mutual cooperation and social solidarity as driving forces for behavioral change.

However, the effectiveness of these interventions is largely determined by several crucial factors, namely personalization, affordability, and sustainability of support. Personalization is important because patient characteristics vary greatly, both in terms of age, socio-cultural background, digital literacy levels, and preferences for forms of support. Without proper adjustments, technology can become irrelevant or even burdensome for patients. Contextually adaptive digital interventions are more effective in maintaining user engagement than a one-size-fits-all approach.

Accessibility is a challenge in implementing technology-based interventions, especially in developing countries. The digital divide is still a major obstacle, where some people do not yet have access to digital devices or a stable internet connection. Therefore, technological solutions must be developed with the principle of inclusivity, such as providing lightweight applications that can be used offline, or integrated with the primary health care system. On the other hand, continued support, whether from medical personnel, family, or the community, is needed to maintain patient motivation. Without ongoing support, many patients experience decreased compliance after the formal intervention program ends. Interventions that combine the human touch—such as digital health counselors or lifestyle coaches with advanced technology have been shown to have longer lasting effects.

Overall, technology- and community-based interventions show great potential in strengthening patient engagement and improving the management of chronic conditions effectively and efficiently. However, to maximize their efficacy, intervention designs need to be holistic, adaptive, and responsive to the socio-economic and cultural contexts of users. The synergistic integration of technology, community support, and evidence-based approaches will be key to creating intervention systems that are not only clinically effective, but also sustainable and widely accessible.

CONCLUSIONS

Adherence to nutrition and physical activity interventions is influenced by psychological, socioeconomic, and health literacy factors. Intrinsic motivations such as a desire to live a healthy lifestyle are more effective in driving lifestyle changes than external pressures. Positive perceptions of the disease and belief in the benefits of the intervention increase patient commitment, while stress and depression can decrease adherence. From a socioeconomic perspective, limited access to healthy foods, exercise facilities, and health services are major barriers for low-income patients. Family and community support can overcome these barriers and improve adherence. High health literacy affects patients' understanding of their treatment and their readiness to make behavioral changes. Patients with low literacy have more difficulty following medical instructions and tend to be less committed to change. Interventions must be tailored to the patient's psychological, social, and literacy levels to be more effective. Adherence to a healthy lifestyle has been shown to reduce HbA1c levels, body weight, and the risk of long-term complications in type 2 diabetes. Educational and participatory approaches are more effective than one-way instructions, and the integration of technology and community support greatly enhances diabetes management by increasing ongoing patient engagement.

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